COMPUTATION AND SUB-MICROSECOND VISUALIZATION OF FINITE TIME SINGULARITIES DURING INTERFACE RUPTURE FOR TESTING FREE SURFACE CODES AND DEVELOPING SCALING THEORIES OF PINCH-OFF

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Free surface flows that exhibit interface rupture are of both practical and fundamental importance. Indeed, a number of emerging and widely practiced applications including ink jet printing, DNA arraying, and microencapsulation rely on single- and two-fluid drop formation where the controlled rupture of a fluid interface plays a central role. On the one hand, production of uniformly-sized drops and prevention of unwanted satellite droplets are key goals in applications. On the other hand, whether the drops will be mono-sized and satellites will not be formed are issues that require a deep understanding of the underlying phenomena of interface pinch-off and singularity formation. Interface rupture and drop formation are now routinely studied using various commercial and in-house free surface flow codes. It is the norm rather than the exception that predictions made with such codes are typically not tested as stringently as they ought to be. Two demanding tests of such codes are that their predictions accord with analytical theories of interface rupture and high-speed visualization experiments. Here we present results obtained with in-house free surface codes that rely on the Galerkin/finite element method for spatial discretization. A special feature of the algorithms is that they are designed to resolve phenomena occurring over length scales differing by at least 4-5 orders of magnitude. The algorithms are applied to study interface pinch-off in situations where drops forming from nozzles break in air, as in ink jet printing, and in another liquid, as in microencapsulation. The accuracy of the computed predictions are demonstrated by showing that they accord with previously published and new scaling theories do not yet exist. Two such examples will be given here where the first involves the rupture of a liquid filament of a non-Newtonian fluid in air and the other that of a bubble in a viscous liquid. It will be shown that the understanding gained through the simulation can be indispensable in the development of scaling theories in situations where the physics is complex.For each congress presentation, an abstract is required that summarizes the presentation.